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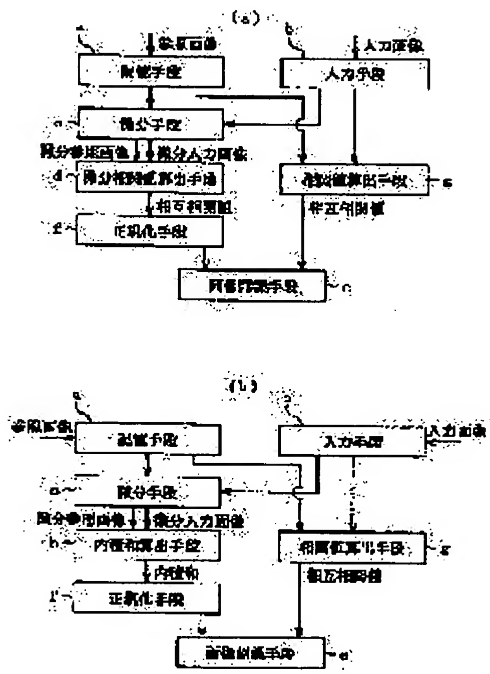
(54) METHOD AND DEVICE FOR PROCESSING PICTURE

(57)Abstract:
PURPOSE: To surely pattern-recognize a picture consisting only of an outline by means of a linear picture and to surely recognize the pattern even if there is the change of the contrast of partial gradation.
CONSTITUTION: A reference picture is previously stored in a storage means (a) and an input picture is inputted in an input means (b). The same differential filters are given to the reference picture and the input picture obtained from the storage means (a) and the input means (b) by a differential means (c), and a differential reference picture and a differential input picture are obtained. The differential reference picture and the differential input picture are inputted to a differential correlation value calculation means (d) or an internal product sum calculation means (h), and the mutual correlation value or the inner product sum is calculated. A picture recognition means (e) obtains the mutual correlative value or the maximum value of the inner product sum, and the relative position relation of the reference picture and the input picture is obtained.



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CLAIMS

[Claim(s)]
[Claim 1] An image-processing method of performing pattern matching of a reference image and an input image which are characterized by providing the following and which were inputted beforehand A production process which hangs the same differential filter on both sides of said reference image and an input image, and obtains a differential reference image and a differential input image A production process which computes a cross-correlation value of these differential reference image and a differential input image A production process which calculates relative physical relationship of said reference image and input image from the maximal value of this cross-correlation value
[Claim 2] An image processing system which performs pattern matching of a reference image and an input image which are characterized by providing the following, and which were inputted beforehand A storage means by which said reference image was memorized beforehand An input means by which said input image is inputted A differential means to hang the same differential filter on both sides of said reference image and an input image, and to obtain a differential reference image and a differential input image A differential correlation value calculation means to compute a cross-correlation value of these differential reference image and a differential input image, and an image recognition means to calculate relative physical relationship of said reference image and input image from the maximal value of this cross-correlation value
[Claim 3] It is the image processing system characterized by being the edge enhancement filter in which said differentiation filter does not have directivity, such as the Laplacian filter, in an image processing system according to claim 2.
[Claim 4] It is the image processing system which is equipped with a normalization means to normalize a correlation value in an image processing system according to claim 2 or 3 by doing the division of said cross-correlation value with standard deviation of a differential reference image and a differential input image, respectively, and is characterized by said image recognition means calculating relative physical relationship of said reference image and input image from the maximal value of a normalized cross-correlation value.
[Claim 5] It is the image processing system which is equipped with a correlation value calculation means compute a cross-correlation value of a reference image and an input image in an image processing system given in either of claims 2, 3, and 4, and is characterized by for said image-recognition means to search for relative physical relationship of said reference image and input image using either a correlation value calculation means or a differential correlation value calculation means based on conditions defined beforehand.
[Claim 6] An image processing system which performs pattern matching of a reference image and an input image which are characterized by providing the following, and which were inputted beforehand A storage means by which said reference image was memorized beforehand An input means by which said input image is inputted A differential means to hang a partial-differential filter of the direction of X, and the direction of Y on both sides of said reference image and an input image, and to obtain two kinds of differential reference images, and a differential input image An inner product sum calculation means to compute the inner product sum of a differential reference image vector which uses a value of these two kinds of differential

reference images, and a differential input image as a component of the direction of X, and the direction of Y, respectively, and a differential input image vector, and an image recognition means to calculate relative physical relationship of said reference image and input image from the maximal value of this inner product sum
[Claim 7] It is the image processing system characterized by being the edge enhancement filter in which said partial-differential filter has directivity, such as the Sobel filter, in an image processing system according to claim 6.
[Claim 8] It is the image processing system which is equipped with a normalization means to normalize the inner product sum in an image processing system according to claim 6 or 7 by doing the division of said inner product sum with standard deviation of a differential reference image and a differential input image, respectively, and is characterized by said image recognition means calculating relative physical relationship of said reference image and input image from the maximal value of the normalized inner product sum.
[Claim 9] It is the image processing system which is equipped with a correlation value calculation means to compute a cross-correlation value of a reference image and an input image in an image processing system given in either of claims 6, 7, and 8, and is characterized by for said image recognition means to search for relative physical relationship of said reference image and input image using either an inner product sum calculation means or a correlation value calculation means based on conditions defined beforehand.
[Claim 10] An image-processing method characterized by having a production process which distinguishes automatically whether it is a suitable image to hang a differentiation filter which has directivity in said reference image in an image-processing method according to claim 1, and for this reference image perform a cross-correlation operation of a differential reference image and a differential input image.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the image-processing method and equipment which perform pattern matching which recognizes the reference image registered out of the input image.
[0002]
[Description of the Prior Art] The technology of performing pattern matching of this reference image and an input image, and searching for the relative physical relationship (gap) of these reference image and an input image for the input image which contains the registered reference image in it conventionally is common knowledge.
[0003] There is the technique of calculating a mutual cross-correlation value as the technique of such pattern matching with a shade image, without making a reference image and an input image binary, and calculating the relative physical relationship (gap) of a reference image and an input image from the maximum of this cross-correlation value. Under the present circumstances, in order to remove the effect by the brightness and contrast of an image, normalizing a cross-correlation value by the average and the variance of an image is performed.
[0004] the operation of a cross-correlation -- the input image S and the reference image T -- Distributions Ds and Dt -- [Equation 1]

$$D_T = 1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}\{T_{ij}-1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}(T_{ij})\}^2 \qquad (1)$$

$$D_S = 1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}\{S_{ij}-1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}(S_{ij})\}^2 \qquad (2)$$

and the covariance Dst of Images S and T -- [Equation 2]

$$D_{ST} = 1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}[\{T_{ij}-1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}(T_{ij})\}\cdot \{S_{ij}-1/(M\cdot N)\cdot\sum_{i=1}^{M}\sum_{j=1}^{N}(S_{ij})\}] \qquad (3)$$

** -- asking -- the correlation coefficient Cst from these distributions Ds and Dt and Covariance Dst -- [Equation 3]

$$Cst = \frac{Dst}{\sqrt{Dt}\cdot\sqrt{Ds}} \qquad (4)$$

It is carried out by computing. Here, the number of the direction of X of the pixel of the field where M should perform a cross-correlation operation, and N are the numbers of the direction of Y, and magnitude of the input image S and the reference image T is made into the equal. (In addition, rootX=(X) 1/2 are shown.) the following -- the same .
[0005] A correlation coefficient Cst takes the value of the range of -1 <=Cst<=1, when the input

image S and the reference image T are in agreement, it takes Cst=1, and when there is no correlation, it takes the value of Cst=0.
[0006] Generally, the input image S is larger than the reference image T, therefore a break and this break are sequentially scanned for the field of the input image C which should take a cross-correlation in magnitude equal to the reference image T, and pattern matching is performed noting that it is the part the input image S and whose reference image T correspond the field where a correlation coefficient Cst takes maximum.
[0007] In pattern matching by the cross-correlation operation, while comparatively being able to ensure recognition even if change of brightness or contrast is between the input image S and the reference image T since matching is performed considering this as a feature of each image, using the information on shade distribution of the whole pattern as it is, there is an advantage that it can recognize even if a pattern has some defects.
[0008]
[Problem(s) to be Solved by the Invention] However, in pattern matching by the conventional cross-correlation operation, when the image which consists only of an outline by the line drawing as shown in drawing 13 (a) was used as the reference image T, there was a problem that incorrect recognition might be carried out since there is little information as a shade.
[0009] Moreover, since pattern matching by the conventional cross-correlation operation is what obtains coincidence of shade distribution of the whole pattern and performs pattern recognition, exact recognition will become difficult if the shade distribution of this pattern itself changes partially. Furthermore, if compression / equalization processing is performed to the input image S or the reference image T for the purpose of improvement in the speed of data processing, since an image as shown in drawing 13 (a) has sharp shade distribution only in the edge section, the possibility of a disadvantage crack, consequently incorrect recognition of the input image [as opposed to the reference image T in the information on shade distribution] S will become high by compression and equalization.
[0010] When it is a thing especially based on objective irregularity in the border line of an image, the image shown in drawing 13 (a) may turn into an image as easily shown in drawing 13 (b), (c), and (d) according to the direction of the light irradiated by this body. There was also a problem that it was recognized as that from which the image shown in drawing 13 (a) and an image as shown in drawing 13 (b), (c), and (d) differ in pattern matching according [the image with which the shade distribution completely differs and shade distribution differs] to a cross-correlation operation.
[0011] Even if the purpose of this invention can perform pattern recognition certainly also about the image which consists only of an outline by the line drawing and moreover has change of the contrast of a partial shade, it is to offer the image-processing method and equipment which can perform positive pattern recognition.
[0012]
[Means for Solving the Problem] If it matches and explains to drawing 1 which is drawing corresponding to a claim, this invention will be applied to an image-processing method and equipment which perform pattern matching of a reference image and an input image which were inputted beforehand. And invention of claim 1 has attained the above-mentioned purpose according to a production process which hangs the same differential filter on both sides of said reference image and an input image, and obtains a differential reference image and a differential input image, the production process which computes a cross-correlation value of these differential reference image and a differential input image, and the production process which calculates relative physical relationship of said reference image and input image from the maximal value of this cross-correlation value. Moreover, a storage means a by which, as for invention of claim 2, said reference image was memorized beforehand A differential means c to hang the same differential filter on both sides of an input means b by which said input image is inputted, said reference image, and an input image, and to obtain a differential reference image and a differential input image The above-mentioned purpose is attained by establishing an image recognition means e to search for relative physical relationship of said reference image and input image from the maximal value of a differential correlation value calculation means d to compute a

cross-correlation value of these differential reference image and a differential input image, and this cross-correlation value. Moreover, invention of claim 3 uses said differentiation filter as an edge enhancement filter without directivity, such as the Laplacian filter, in an image processing system according to claim 2. Invention of claim 4 establishes a normalization means f to normalize a correlation value, and seems furthermore, to calculate relative physical relationship of said reference image and input image in an image processing system according to claim 2 or 3 from the maximal value of a cross-correlation value with which said image recognition means e was normalized by doing the division of said cross-correlation value with standard deviation of a differential reference image and a differential input image, respectively. Invention of claim 5 establishes a correlation value calculation means g compute a cross-correlation value of a reference image and an input image in an image processing system given in either of claims 2, 3, and 4, and seems furthermore, to search for relative physical relationship of said reference image and input image using either the correlation value calculation means g or the differential correlation value calculation means d based on conditions as which said image-recognition means e was determined beforehand. A storage means a by which, as for invention of claim 6, said reference image was memorized beforehand on the other hand A differential means c to hang a partial-differential filter of the direction of X, and the direction of Y on both sides of an input means b by which said input image is inputted, said reference image, and an input image, and to obtain two kinds of differential reference images, and a differential input image An inner product sum calculation means h to compute the inner product sum of a differential reference image vector which uses a value of these two kinds of differential reference images, and a differential input image as a component of the direction of X, and the direction of Y, respectively, and a differential input image vector The above-mentioned purpose is attained by establishing an image recognition means f to calculate relative physical relationship of said reference image and input image from the maximal value of this inner product sum. Moreover, invention of claim 7 uses said partial-differential filter as an edge enhancement filter with directivity, such as the Sobel filter, in an image processing system according to claim 6. Invention of claim 8 establishes a normalization means f to normalize the inner product sum, and seems furthermore, to calculate relative physical relationship of said reference image and input image in an image processing system according to claim 6 or 7 from the maximal value of the inner product sum by which said image recognition means e was normalized by doing the division of said inner product sum with standard deviation of a differential reference image and a differential input image, respectively. Invention of claim 9 establishes a correlation value calculation means g compute a cross-correlation value of a reference image and an input image in an image processing system given in either of claims 6, 7, and 8, and seems and to search for relative physical relationship of said reference image and input image using either the inner product sum calculation means h or the correlation value calculation means g based on conditions as which said image recognition means e was determined beforehand. Moreover, in an image-processing method according to claim 1, invention of claim 10 hangs a differentiation filter which has directivity in said reference image, and is equipped with a production process which distinguishes automatically whether it is a suitable image for this reference image to perform a cross-correlation operation of a differential reference image and a differential input image.

[0013]

[Function]

- The same differential filter is hung on both a claim 1- reference image and an input image, and a differential reference image and a differential input image are obtained. From these differential reference image and a differential input image, these cross-correlation values are computed and the relative physical relationship of a reference image and an input image is searched for from the maximum of this cross-correlation value.

- The reference image is beforehand memorized by the claim 2-storage means a, and an input image is inputted into the input means b. The same differential filter is hung on the both sides by the differential means c, and, as for the reference image and input image which are obtained from these storage means a and the input means b, a differential reference image and a differential input image are called for. These cross-correlation values are computed by these differential

reference image and a differential input image being inputted into the differential correlation value calculation means d, the maximal value of this cross-correlation value is calculated by the image recognition means e, and the relative physical relationship of a reference image and an input image is searched for.
- The reference image is beforehand memorized by the claim 6-storage means a, and an input image is inputted into the input means b. The partial-differential filter of the direction of X and the direction of Y is hung on the both sides by the differential means c, and, as for the reference image and input image which are obtained from these storage means a and the input means b, two kinds of differential reference images and a differential input image are called for. The inner product sum of the differential reference image vector which uses the value of these two kinds of differential reference images and a differential input image as the component of the direction of X and the direction of Y, respectively, and a differential input image vector is computed by these two kinds of differential reference images and a differential input image being inputted into the inner product sum calculation means h. And the relative physical relationship of said reference image and input image is calculated from the maximal value of this inner product sum by the image recognition means e.
[0014]
[Example]
- 1st example- drawing 2 is the block diagram showing the 1st example of the image-processing method by this invention, and equipment. In this drawing, 1 is an image processing system concerning this example, this image processing system 1 consists of a microcomputer, memory, etc., it has CPU board (this is hereafter called host CPU board) 2 which controls input/output operation of an image, correlation data-processing actuation, etc., an image memory 3, and a high speed processor 4, and these host CPU board 2, the image memory 3, and the high speed processor 4 are connected with the system bus 5 and the data bus 6, respectively. In the memory of the host CPU board 2, reference image data is inputted and stored beforehand.
[0015] 7 is image sensors, such as a TV camera, and the image picturized by this image sensor 7 is stored in an image memory 3 as input (digital) image data through A/D converter 8. 9 is indicating equipments, such as TV monitor, and the image data in an image memory 3 is outputted to this indicating equipment 9 through D/A converter 10. 11 is the interface section and a processing result is outputted to the external application section (illustration abbreviation) through this interface section 11.
[0016] Next, actuation of this example is explained with reference to the flow chart of drawing 3 and drawing 4 - drawing 11 . When a program begins, at step S1, the image which should be carried out pattern matching with an image sensor 7 is picturized, and input image data is stored in an image memory 3 through A/D converter 8. At step S2, reading appearance of a part of reference image data stored in the memory of the host CPU board 2 is carried out, and the normalization cross-correlation processing which this reference image data by which reading appearance was carried out mentions later is presented. At step S3, normalization cross-correlation processing with the reference image data by which reading appearance was carried out at step S2, and the input image data in an image memory 3 is performed.
[0017] Drawing 4 is drawing showing the details of the normalization cross-correlation processing in this example. From an image memory 13, as shown in drawing 11 , reading appearance of the input image data S0 of the magnitude corresponding to sequential reference image data is carried out from the upper left. In the data compression average section 15, for data-processing time amount compaction, the input image data S0 is divided into the field which consists of pxq pixels, and compression equalization of image data is performed by data processing of representing the data of a field with the average value of the data of the pxq individual in the field. Similarly, compression equalization of image data is performed to the reference image data T0 by which reading appearance was carried out in step S2 from the reference image storing section 14 in the host CPU board 2. In the gradation transducer 16, gray scale conversion of reference image data T' by which compression equalization was carried out is performed so that the result of a cross-correlation may become good.
[0018] In the sum-of-products operation part 17, the sum of products of reference image data T

(gray scale conversion is also performed about this data) to which compression equalization was performed, and input image data S calculate. These sum of products are expressed with sigmasigmaSij-Tij when size of reference image data T after compression equalization is made into MxN (sigmasigma is the same here the following showing total between 1 <=i<=M and 1 <=j<=N).

[0019] on the other hand, in the accumulation section 18, the accumulation sum sigmasigmaSij of input image data S to which compression equalization was performed asks -- having -- square -- in an adder unit 19, the sum of squares sigmasigmaSij2 is called for. And in the standard deviation operation part 20, standard deviation rootDs (refer to (2) types) is calculated using these accumulation sum sigmasigmaSij and the sum of squares sigmasigmaSij2.

[0020] similarly, in the accumulation section 18, the accumulation sum sigmasigmaTij of reference image data T to which compression equalization and gray scale conversion were performed asks -- having -- square -- in an adder unit 19, the sum of squares sigmasigmaTij2 is called for. And in the standard deviation operation part 20, standard deviation rootDt (refer to (1) type) is calculated using these accumulation sum sigmasigmaTij and the sum of squares sigmasigmaTij2.

[0021] And in the normalization correlation operation part 21, while Covariance Dst (refer to (3) types) is called for using the sum of products sigmasigmaSijTij called for by the sum-of-products operation part 17, a correlation coefficient Cst (refer to (4) types) is called for using standard deviation rootDs, rootDt, and Covariance Dst which were called for by the standard deviation operation part 20.

[0022] The above normalization cross-correlation operation shifts at a time 1 pixel of input image data S0 by which reading appearance is carried out from the image memory 13 one by one from the upper left to the lower right, as shown in drawing 11 , and it is repeatedly performed about each input image data S0. And the above-mentioned maximum and the above-mentioned coordinate value of a correlation coefficient Cst are temporarily memorized in the memory of the host CPU board 2.

[0023] In step S4, if it is judged whether it is beyond the threshold that the maximum of a correlation coefficient Cst defined beforehand and it is judged beyond with a threshold, the location of the input image data S0 where the maximum of this correlation coefficient Cst was obtained will be outputted outside through the interface section 11. On the other hand, when judged with the maximum of a correlation coefficient Cst not exceeding a threshold, a program shifts to step S5 and outline cross-correlation processing mentioned later is performed.

[0024] At step S5, reading appearance of a part of reference image data stored in the memory of the host CPU board 2 is carried out, and the outline cross-correlation processing which this reference image data by which reading appearance was carried out mentions later is presented. At step S6, the differentiation filter which has the all directions tropism of drawing 7 (a), (b), and drawing 8 (a) and (b) to the reference image data by which reading appearance was carried out at step S5 is hung according to an individual, and it asks for the accumulation sum about each differentiation filter. The differentiation filter shown in drawing 7 is the Sobel (Sobel) differentiation filter which has the directivity of the direction of X, and the direction of Y, and the differentiation filter shown in drawing 8 is a filter which has the directivity of the XY direction (direction expressed with linear-function Y=X or Y=-X). Therefore, when the reference image data by which reading appearance was carried out at step S5 has the border line which met in the direction of these X, the direction of Y, or the XY direction, the accumulation sum of the differentiation filter and reference image data which have the directivity which met in the direction shows a significant value.

[0025] If it is judged whether it is below the threshold as which the value of each four accumulation sums was beforehand determined at step S7 and it is judged with there being the following [or more three threshold] among the four accumulation sums, it will be regarded as a thing only with the fixed direction which does not have the outline of a pattern or has a pattern, and a program will return to step S5. If judged with there being no following [or more three threshold] among the four accumulation sums, it will consider that reference image data is suitable, and will shift to step S7. At step S7, outline cross-correlation processing later

mentioned using this reference image data is performed.
[0026] Drawing 5 is drawing showing the details of the outline cross-correlation processing in this example. From an image memory 23, as shown in drawing 11 , reading appearance of the input image data S0 of the magnitude corresponding to sequential reference image data is carried out from the upper left. As for this input image data S0, compression equalization is performed by the data compression average section 25 for data-processing time amount compaction. Similarly, compression equalization of image data is performed by the data compression average section 25 to the reference image data T0 by which reading appearance was carried out in step S5 from the reference image storing section 24 in the host CPU board 2.

[0027] In the direction differential processing section 26 of X, the direction Sobel operation filter of X of drawing 7 (a) is hung on input image data S and reference image data T which gave compression equalization, and the differential values Sy and Ty (henceforth the direction differential value of X) which emphasized the outline component of the direction of Y are calculated. Similarly, in the direction differential processing section 27 of Y, the direction Sobel operation filter of Y of drawing 7 (b) is hung on input image data S and reference image data T which gave compression equalization, and the differential values Sx and Tx (henceforth the direction differential value of Y) which emphasized the outline component of the direction of X are calculated. The vectors S and T (about a vector value, an underline is hereafter given in the semantics distinguished from a scalar value.) as shown in drawing 10 which makes a zero the pixel G of 3x3 matrices which constitute this differentiation filter from drawing 6 in the differentiation filter generally displayed hereafter (henceforth an attention pixel), and shows the strength and directivity of an outline of an image however, the vector mark according [on drawing and a formula and] to the usual arrow head -- displaying -- it thinks. and the ingredients label of these vectors S and T -- and (Sx, Sy) (Tx, Ty) it carries out.
[0028] square -- in an adder unit 28, the sum of squares of the direction differential values Sx and Tx of X acquired in the above-mentioned direction differential processing section 26 of X and the direction differential processing section 27 of Y and the direction differential values Sy and Ty of Y is called for. This sum of squares is expressed with sigmasigmaSxij2, sigmasigmaTxij2, and sigmasigmaSyij2 and sigmasigmaTyij2 when size of reference image data T after compression equalization is made into MxN.
[0029] Here, although concentration was normalized in the conventional normalization cross-correlation processing shown in drawing 4 by deducting an average concentration value from the concentration value of image each point, since the differentiation filter is given to each image data in outline cross-correlation processing of this example, a differential value becomes 0 in the field where a concentration value is fixed. Therefore, the magnitude of the outline vectors S and T is not influenced by uniform concentration gradation change of the whole image. It means that the need that this deducts and normalizes the average of an outline vector to an outline vector is lost.
[0030] Therefore, in the standard deviation operation part 29, (5) types are called for as standard deviation of the outline vector in an input image from the sums of squares sigmasigmaSxij2 and sigmasigmaSyij2 by the side of an input image, and (6) types are called for as standard deviation of the outline vector in a reference image from the sums of squares sigmasigmaTxij2 and sigmasigmaTyij2 of a reference image.
[Equation 4]

$$\sigma_{S0} = \sqrt{\left\{ \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (\vec{S}_{ij})^2 \right\}}$$

$$= \sqrt{\left\{ \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (Sx_{ij}^2 + Sy_{ij}^2) \right\}} \qquad (5)$$

$$\sigma_{T0} = \sqrt{\left\{ \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (\vec{T}_{ij})^2 \right\}}$$

$$= \sqrt{\left\{ \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (Tx_{ij}^2 + Ty_{ij}^2) \right\}} \qquad (6)$$

In addition, since the normalized arithmetic mentioned later is impossible when these standard deviation is 0, stop subsequent data processing, an input image is made to shift to the location of a degree, and reduction of use memory and compaction of the processing time can also be aimed at.

[0031] In the sum-of-products operation part 30, sum-of-products sigmasigmaSyij-Tyij of the direction differential value Tyij of X of reference image data and the direction differential value Syij of X of input image data which are acquired from the direction differential processing section 26 of X is called for. Similarly, sum-of-products sigmasigmaSxij-Txij of the direction differential value Txij of Y of reference image data and the direction differential value Sxij of Y of input image data which are acquired from the direction differential processing section 27 of Y is also called for. In the vector inner product sum operation part 31, the sum of sum-of-products sigmasigmaSyij-Tyij of the direction differential value of X and sum-of-products sigmasigmaSxij-Txij of the direction differential value of Y which were called for by the sum-of-products operation part 30 is computed. In this way, the inner product sum of the vectors S and T shown in drawing 10 between each pixel to which the reference image T and the input image S correspond [several 5]

$$\rho_{V0} = \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (\vec{T}_{ij} \cdot \vec{S}_{ij})$$

$$= \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (|\vec{T}_{ij}|\ |\vec{S}_{ij}| \cos\theta_{ij})$$

$$= \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (Tx_{ij}Sx_{ij} + Ty_{ij}Sy_{ij}) \qquad (7)$$

**** ** and the correlation value which considered both the directivity of an outline and strength between the reference image T and the input image S will be acquired. That is, if the inner product sum of these vectors S and T takes maximum as shown in drawing 10 , the directivity and strength of an outline of vector S=T T, i.e., a reference image, and the input image S are in agreement, and if the inner product sum of Vectors S and T is 0, it is shown in reverse at the directivity of the outline of vector S**T T, i.e., a reference image, and the input image S that there is no functionality. When there is no necessity of identifying intentionally the image which shade contrast has reversed as shown in drawing 13 (b) and (c), among these when sum of products are zero or less, subsequent data processing can be stopped, and reduction of use memory and compaction of the processing time can be aimed at by making an input image shift to the location of a degree.

[0032] In the outline vector correlation coefficient operation part 22, the average of vector inner product sum sigmasigma (TxijSxij+TyijSyij) called for by the vector inner product sum operation part 31 By standard deviation value [of the outline vector by the side of the reference image called for by the standard deviation operation part 29] root [1/(M-N) andsigmasigma (Txij2+Tyij2)], and standard deviation value [of the outline vector by the side of an input image] root [1/(M-N) andsigmasigma (Sxij2+Syij2)], a division is done respectively and it normalizes. The

outline vector correlation coefficient Cv is computed as be alike. This outline vector correlation coefficient Cv is [Equation 6].

$$\mathrm{Cv} = \frac{\rho V_0}{(\sigma T_0)(\sigma S_0)} \qquad (8)$$

It is come out and expressed.

[0033] Moreover, when an outline pattern exists on the image which has a fixed concentration gradient in the fixed direction, it is a degree type [several 7].

$$\begin{aligned}
\sigma S_1 &= \sqrt{\ } \left[\left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} \left\{ \vec{S}_{ij} - \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} \vec{S}_{ij} \right\}^2 \right. \\
&= \sqrt{\ } \left[\left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (\vec{S}_{ij})^2 - \left(\frac{1}{MN}\right)^2 \left(\sum_{i=1}^{M} \sum_{j=1}^{N} \vec{S}_{ij} \right)^2 \right] \\
&= \sqrt{\ } \left[\left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (Sx_{ij}^2 + Sy_{ij}^2) \right. \\
&\qquad \left. - \left(\frac{1}{MN}\right)^2 \left\{ \left(\sum_{i=1}^{M} \sum_{j=1}^{N} Sx_{ij} \right)^2 + \left(\sum_{i=1}^{M} \sum_{j=1}^{N} Sy_{ij} \right)^2 \right\} \right] \qquad (9)
\end{aligned}$$

$$\begin{aligned}
\sigma T_1 &= \sqrt{\ } \left[\left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} \left\{ \vec{T}_{ij} - \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} \vec{T}_{ij} \right\}^2 \right] \\
&= \sqrt{\ } \left[\left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (\vec{T}_{ij})^2 - \left(\frac{1}{MN}\right)^2 \left(\sum_{i=1}^{M} \sum_{j=1}^{N} \vec{T}_{ij} \right)^2 \right] \\
&= \sqrt{\ } \left[\left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (Tx_{ij}^2 + Ty_{ij}^2) \right. \\
&\qquad \left. - \left(\frac{1}{MN}\right)^2 \left\{ \left(\sum_{i=1}^{M} \sum_{j=1}^{N} Tx_{ij} \right)^2 + \left(\sum_{i=1}^{M} \sum_{j=1}^{N} Ty_{ij} \right)^2 \right\} \right] \qquad (10)
\end{aligned}$$

[Equation 8]

$$\rho v_1 = \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} [\{\vec{T}_{ij} - \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} \vec{T}_{ij}\}$$

$$\cdot \{\vec{S}_{ij} - \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} S_{ij}\}]$$

$$= \left(\frac{1}{MN}\right) \{\sum_{i=1}^{M} \sum_{j=1}^{N} (\vec{T}_{ij} \cdot \vec{S}_{ij}) - \left(\frac{1}{MN}\right) (\sum_{i=1}^{M} \sum_{j=1}^{N} \vec{S}_{ij}) \cdot (\sum_{i=1}^{M} \sum_{j=1}^{N} \vec{T}_{ij}) \}$$

$$= \left(\frac{1}{MN}\right) \{\sum_{i=1}^{M} \sum_{j=1}^{N} (| \vec{T}_{ij} | \ | \vec{S}_{ij} | \cos \theta_{ij})$$

$$- \left(\frac{1}{MN}\right) (| \sum_{i=1}^{M} \sum_{j=1}^{N} \vec{S}_{ij} | \ | \sum_{i=1}^{M} \sum_{j=1}^{N} \vec{T}_{ij} | \cos \Phi)\}$$

$$= \left(\frac{1}{MN}\right) [\sum_{i=1}^{M} \sum_{j=1}^{N} (Tx_{ij} Sx_{ij} + Ty_{ij} Sy_{ij})$$

$$- \left(\frac{1}{MN}\right) \{(\sum_{i=1}^{M} \sum_{j=1}^{N} Sx_{ij}) (\sum_{i=1}^{M} \sum_{j=1}^{N} Tx_{ij})$$

$$+ (\sum_{i=1}^{M} \sum_{j=1}^{N} Sy_{ij}) (\sum_{i=1}^{M} \sum_{j=1}^{N} Ty_{ij})\}] \qquad (11)$$

The outline vector correlation coefficient Cv is [Equation 9] by it being alike, and deducting and normalizing the average value of each outline vector to an outline vector so that it may be shown.

$$Cv = \frac{\rho v_1}{(\sigma_{T1}) \ (\sigma_{S1})} \qquad (12)$$

It is come out and expressed. By this normalization, even when an input image has change of a fixed concentration gradient, normalized pattern matching with a template image can be performed.

[0034] As shown in (a) of drawing 13 , (b), (c), and (d), when an outline pattern symmetrical with the upper and lower sides and right and left exists on the image of concentration gradation regularity 1/(M-N) of average value and sigmasigmaSij of the outline vector by the side of 0 and an input image are set to 0 by 1/(M-N) of average value, and sigmasigmaTij of the outline vector by the side of a reference image. (9) The standard deviation of the outline vector by the side of the input image of a formula is in agreement with (5) types. (10) As for the average value of the vector inner product sum of (11) types, the standard deviation of the outline vector correlation coefficient Cv of (12) types of the outline vector by the side of the reference image of a formula will correspond with (8) types in accordance with (7) types therefore in accordance with (6) types.

[0035] The range of the value of a correlation coefficient Cv is -1 <=Cv<=+1, it is shown that the direction and magnitude of the outline are in agreement between the input image S and the reference image T at the time of Cv=1, it is shown that the direction is 180-degree hard flow at the time of Cv=-1, and it is shown that there is no correlation of a direction at the time of Cv=0. Therefore, that what is necessary is just to catch the location near Cv=-1 when identifying intentionally the image which shade contrast has reversed completely, only the form of a border line is made an issue of, and it computes the maximum of absolute value |Cv| and should just identify it to disregard shade contrast.

[0036] The above normalization cross-correlation operation shifts at a time 1 pixel of input image data S0 by which reading appearance is carried out from the image memory 23 one by one from the upper left to the lower right, as shown in drawing 11 , and it is repeatedly performed about each input image data S0. And the maximum of the above-mentioned correlation coefficient Cv is temporarily memorized in the memory of the host CPU board 2. The location of the input image data S0 where the maximum of this correlation coefficient Cv was obtained is outputted to the external application section 12 through the interface section 11.
[0037] The procedure shown above can perform pattern matching of an input image and a reference image. By this example, the direction of X and the direction Sobel filter of Y are hung on these input image and a reference image here. Since the vectors S and T which reach in the strength of the outline of each image from the differential value, and have directivity are searched for and the functionality (outline) of an image is searched for using the inner product sum of these vectors S and T For example, there are few possibilities of carrying out incorrect recognition for the image which consists only of an outline by line drawing like drawing 13 (a) like the conventional cross-correlation operation also as a reference image, and they can perform positive pattern recognition. Similarly, as shown in drawing 13 , even if change of the contrast of a partial shade is between an input image and a reference image, since the outline image itself does not influence change of the contrast of a shade, it can perform pattern recognition more positive than the conventional cross-correlation operation.
[0038] And since pattern recognition by the conventional cross-correlation operation is performed to the beginning, and the outline cross-correlation operation is performed when this result is not good, there is also an advantage that the operation of these both sides can perform certain and exact pattern recognition to a variety of images.
[0039] - Modification of the 1st example - Although the differentiation filter which has directivity in an input image and a reference image, i.e., a partial-differential filter, was hung and the differential value had been acquired in the 1st above-mentioned example, a differential value may be acquired using the Laplacian (namely, total differential) filter in which a noise does not have directivity as shown in drawing 9 (a) and (b) to few images with a clear edge comparatively. In this case, a differential value does not have characteristic directivity but turns into a scalar value which has only strength.
[0040] The outline scalar correlation coefficient Cs which shows correlation of only the strength of an edge between the reference image T and the input image S is [Equation 10].

$$\sigma_{S_2} = \sqrt{\left\{ \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} S_{ij}^2 \right\}} \quad (13)$$

$$\sigma_{T_2} = \sqrt{\left\{ \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} T_{ij}^2 \right\}} \quad (14)$$

[Equation 11]

$$\rho_{S_0} = \left(\frac{1}{MN}\right) \sum_{i=1}^{M} \sum_{j=1}^{N} (T_{ij} S_{ij}) \quad (15)$$

It is [Equation 12] more.

$$Cs = \frac{\rho_{S_0}}{(\sigma_{T_2})\ (\sigma_{S_2})} \quad (16)$$

It is come out and expressed. Moreover, in outline scalar correlation, even when change of a fixed concentration gradient exists in an input image, since secondary differential values, such as the Laplacian filter, are always set to 0, they do not need to deduct the average of each outline scalar. The value of a correlation coefficient Cs takes the range of $-1 \le Cs \le +1$.
[0041] Therefore, the same operation effect as the 1st above-mentioned example can be acquired also by this example. Especially, in this example, it becomes unnecessary to hang twice the operation filter which has directivity like the Sobel filter in the direction of X, and the direction of Y, and data-processing time amount can be shortened further. In addition, in drawing

5 , a dotted line arrow head shows the flow of processing of outline scalar correlation coefficient calculation.

[0042] - 2nd example- drawing 12 is a flow chart which shows actuation of the 2nd example of the image-processing method by this invention, and equipment. In this example, after defining using any of normalization cross-correlation processing (step S23) or outline cross-correlation processing (step S28) pattern recognition is performed beforehand, therefore reading an input image at step S21, in step S20, it is judged whether processing [which] is performed, it follows this judgment result, and shifts, and that processing is performed. In addition, other actuation is the same as that of the 1st above-mentioned example, therefore shows the number which added 20 to the step number of the 1st example in drawing 12 , and omits the explanation. Therefore, the same operation effect as the 1st above-mentioned example can be acquired also by this example.

[0043] In addition, in correspondence with an example and a claim, an image sensor 7 and A/D converter 8 constitute an input means, and, as for the host CPU board 2, the image memory 3 constitutes a differential means, a differential correlation value calculation means, the inner product sum calculation means, the normalization means, the correlation value calculation means, and the image recognition means for the storage means, respectively.

[0044] In addition, the details are not limited to an above-mentioned example, but various modifications are possible for the image-processing method of this invention, and equipment. You may make it switch automatically normalization cross-correlation processing and outline cross-correlation processing with the property of a reference image in step S20 of drawing 12 as an example.

[0045]

[Effect of the Invention] Since according to this invention a differentiation filter is hung on an input image and a reference image and the functionality (outline) of an image is searched for using the differential value as explained to details above Even if change of the contrast of a partial shade is between the input image also as a reference image, and a reference image about the image which consists only of an outline by the line drawing, there are few possibilities of carrying out incorrect recognition like the conventional cross-correlation operation, and they can perform positive pattern recognition. Moreover, according to invention of claim 5 and claim 8, there is also an advantage that the operation of the both sides of a cross-correlation operation and an outline cross-correlation operation can perform certain and exact pattern recognition to a variety of images.

[Translation done.]